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# Optical Arrangement for the Spectral Fanning Out of a Light Beam

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The invention concerns an optical arrangement for the spectral fanning out of a light beam, preferably in the detection beam path of a confocal microscope, especially for the subsequent splitting of the fanned out beam out of its dispersion plane and for the detection of the split up spectral ranges, whereby the incoming light beam is focused on a pinhole.

## BACKGROUND OF THE INVENTION

Optical arrangements of the type in question here have been known from practice for a fairly long time, and specifically in connection with the simultaneous detection of several spectral ranges of a light beam, which is done with a so-called multi-band detector. A multi-band detector of this type makes for a complex optical arrangement that prior to this, with additional optics, has enabled multiple focusing.

If in the detection beam path of a confocal microscope one wants first to fan out the beam spectrally and then split it up out of its dispersion plane into individual spectral ranges, a high dynamic response for the separation of the excitation light is desired. However, diffractions that stem from the shape of the detection pinhole stand fundamentally in opposition to such a high dynamic, whereby in particular secondary maxima of the diffraction function in the spectrally separated detection range cause problems.

## SUMMARY OF THE INVENTION

The object of the invention is therefore to configure and further develop an optical arrangement of the type in question such that a splitting of the fanned out beam with a suppression of interfering diffraction portions in the spectral range is possible.

The optical arrangement of the type in question according to the invention fulfills the aforementioned purpose by means of a pinhole having ~~the features of patent claim 1. According to the claim~~,

~~such an arrangement is characterized in that the pinhole has~~ a polygonal passageway for the light beam.

According to the invention, first of all it has been recognized that the form of the pinhole is responsible for the diffraction pattern that occurs for the various colors in the focus plane, or in the dispersion plane. While specifically a pinhole with a round passageway has annular secondary maximum diffraction values with limited dynamic response because of the diffraction effect occurring here, by using a pinhole with a polygonal passageway a completely different diffraction pattern results, namely a diffraction pattern whose secondary maximum diffraction values are arranged in lines that cross each other. In any case it is possible, in light of such an arrangement, to detect the primary diffraction maxima and to suppress the problematic secondary diffraction phenomena.

With regard to a concrete configuration of the pinhole or of the passageway formed there, it is of further benefit if this – polygonal – passageway is configured symmetrically. In this case the passageway could be of triangular or four-cornered configuration, whereby in the context of a four-cornered configuration the symmetrical – and therefore rectangular – form is especially advantageous. From this there results specifically a completely specialized diffraction pattern of the pinhole for various spectral ranges or colors, namely a spectral cross, whereby the axes of the cross meet in the secondary diffraction maxima. Secondary diffraction maxima lying in between are less problematic in the detection or splitting.

Screens that are preferably variable could also be arranged in the beam path in front of or behind the pinhole. These screens are used to suppress diffraction maxima or diffraction phenomena of a higher order.

In principle simultaneous detection of several spectral ranges of a light beam is possible without additional measures if the light beam is first spectrally fanned out and then a splitting of the fanned out beam out of the dispersion plane is performed. The splitting of the fanned out beam out of the dispersion plane is accomplished by means of a special optical

arrangement, whereby the partial beams split up into spectral ranges or the spectral ranges themselves are detected, and indeed are detected simultaneously. The important thing here is that a fanning out of the light beam precedes the actual splitting into spectral ranges so that the splitting out of the dispersion plane can occur on the fanned out beam. In any case a multiple focusing with additional optics is not necessary here.

In principle two optically arrangements are provided here, namely once for the spectral fanning out of the light beam and another time for splitting and subsequent detection. The pinhole on which the incoming lightbeam is focused is situated upstream of the arrangement for spectral fanning out of the light beam, whereby the pinhole can be situated directly downstream of a laser scanner. What is important here, in any case, is the recognition that the form of the passageway in the pinhole creates a specific diffraction pattern of the fanned out light beam in the dispersion plane.

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From the pinhole, the beam in some cases runs through the previously mentioned variable screen to focusing optics and dispersion means. The dispersion means can be designed as a prism for an especially simple construction. Focusing optics, which can in turn comprise a lens arrangement, are arranged both in front of and behind the dispersion means or prism.

The beam running divergent from the path from the pinhole to the prism is focused through the focusing optics into the gap/detector arrangement situated downstream at which point the splitting into spectral ranges occurs.

Regarding the gap/detector arrangement, it is advantageous if special color selection gaps are provided there in the focusing plane or dispersion plane of the fanned out beam, said color selection gaps being in turn arranged and aligned such that diffraction can be screened out at the detection gap.

## BRIEF DESCRIPTION OF THE DRAWINGS

There are then various possibilities for configuring and developing further the present invention in an advantageous way. On the one hand one can refer to the claims ~~based on patent claim 1~~; on the other hand, one can refer to the following explanation of an embodiment of the invention with reference to the drawings. Generally preferred configurations and further developments of the concept are explained in connection with the explanation of the preferred embodiment of the invention. The drawings show:

Fig. 1 in a schematic representation, a traditional optical arrangement with a pinhole having a round passageway,

Fig. 2 in a schematic representation, an embodiment of an optical arrangement according to the invention, whereby the pinhole has a square passageway and

Fig. 3 in a schematic representation, the entire optical arrangement comprising the fanning out of the light beam, the splitting of the fanned out beam and the detection.

## DETAILED DESCRIPTION OF THE DRAWINGS

Figures 1 through 3 show an optical arrangement for the spectral fanning out of a light beam 1, the light beam 1 here being in the detection beam path of a confocal microscope (not shown). After the spectral fanning out of the light beam 1, there is a splitting of the fanned out beam 2 from out of its dispersion plane 3. A detection of the split spectral ranges 4 is accomplished by means of suitable detectors 5. The overall connection can be inferred from Fig. 3, whereby detection gaps 6 are provided there for selection of the spectral ranges 4. The simple representation used here serves to clarify the operation. Additional details are left out in order to give an overview.

The optical arrangement shown in Fig. 1 is an arrangement of the conventional type, i.e. an arrangement known in the art, in which the incoming light beam 1 is focused on a pinhole 7 with a round passageway 8. From there out the beam runs through focusing optics

9 and a dispersion means configured as a prism 10 and through additional focusing optics 11 into a gap/detector arrangement 12 indicated only in Fig. 3, whereby due to a pinhole 7 with a round passageway 8 in the dispersion plane 3 a completely specialized diffraction pattern 13 for different colors is produced. Annularly depicted secondary diffraction maxima limit the dynamic response of the known system.

Fig. 2 shows an optical arrangement according to the invention in which the pinhole 7 has a polygonal passageway 8, specifically a four-cornered or rectangular passageway. This pinhole 7 or the passageway 8 realized there, in contrast to the traditional optical arrangement, creates a completely different diffraction pattern 13 in the dispersion plane 3, specifically because of the diffraction maxima 16 arranged in two lines 14 and 15.

Fig. 2 shows in merely symbolic fashion that the detection gaps 6 are arranged and aligned such that the diffraction phenomena at the detection gap 6 can be screened, since at most negligible secondary maximum diffraction values lie along the detection line 17.

However, what is important is that the configuration of the pinhole, or its passageway 8, is responsible for the diffraction pattern 13, whereby with a polygonal passageway 8, the pinhole 7 yields a diffraction pattern 13 that enables a screening of the secondary maxima of the diffraction phenomena by means of suitable detection gaps 6, thus specifically with the use of a rectangular opening 8 of the pinhole 7 by means of spectral splitting diagonal to the diffraction cross.

## Reference number list

| | |
|---|---|
| 1 | light beam |
| 2 | fanned out beam |
| 3 | dispersion plane |
| 4 | spectral range |
| 5 | detector |
| 6 | detection gap |
| 7 | pinhole |
| 8 | passageway |
| 9 | focusing optics |
| 10 | prism |
| 11 | focusing optics |
| 12 | gap/detector arrangement |
| 13 | diffraction pattern |
| 14 | line |
| 15 | line |
| 16 | diffraction maxima |
| 17 | detection line |